The Effect of Flow and Agitation on Ultrasonic Fields

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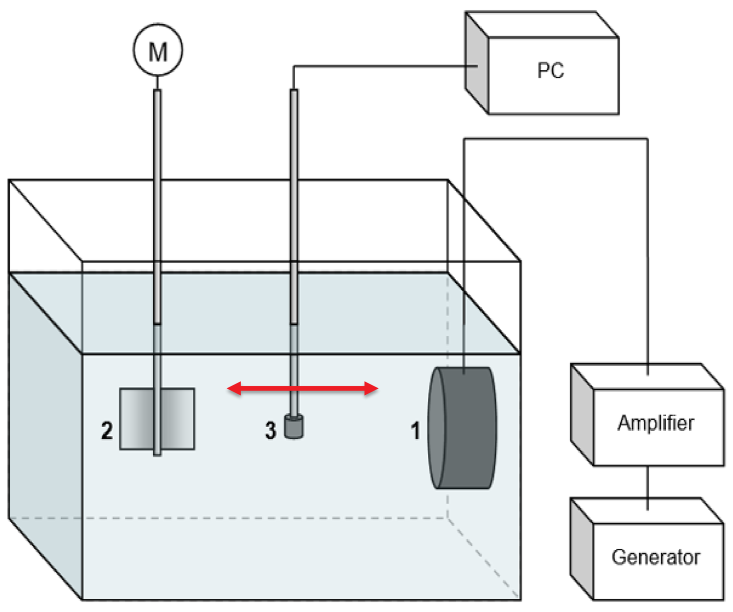
Introduction

In order to successfully design and scale up ultrasonic batch and continuous reactors, knowledge is needed on the effect of flow and agitation. Earlier studies show contradicting results involving both attenuation[1],[2],[3],[4] and enhancement [5],[6],[7],[8] of the ultrasonic activity, indicating this matter is not fully understood. A comparison between agitated batch and flow reactors using different measurement techniques is presented here to correlate fluid motion with local and overall acoustic intensity.

Materials and methods

Local ultrasonic intensity[1]

Thermocouple coated with absorbing material moving along the axis of the transducer measures:



i) Temperature rise

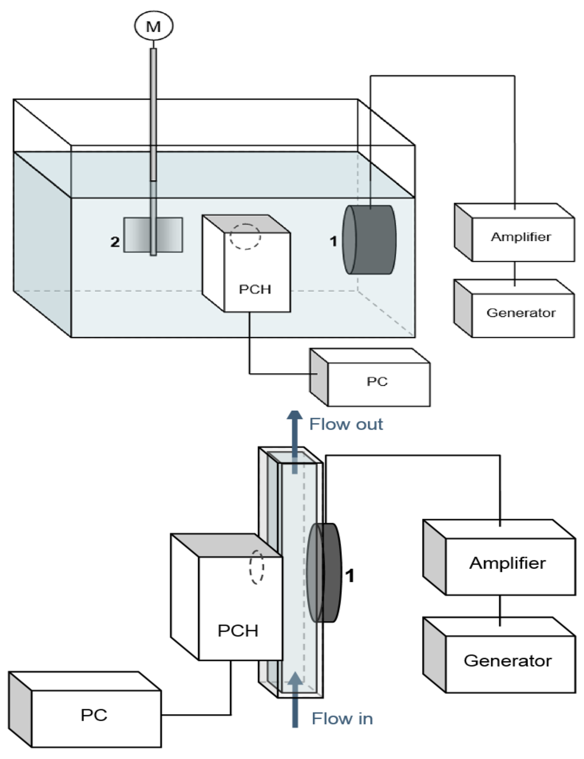
$$I = \frac{\rho_a C_{p,a}}{\mu_a}\boxed{\left(\frac{dT}{dt}\right)_0}$$

ii) Temperature difference

$$I = \frac{hA_a}{\mu_a V_a}\boxed{(T_{eq} - T_0)}$$

Overall ultrasonic intensity[9]

Photon counting head measures sonoluminescence signal before (SL_0) and after (SL) addition of quenchers:



i) n-Propanol (100 - 200 mM)

SL/SL_0 =/↑: Coalescence effects + **Transient** cavitation

SL/SL_0 ↓: **Stable** cavitation

ii) Acetone (100 - 200 mM)

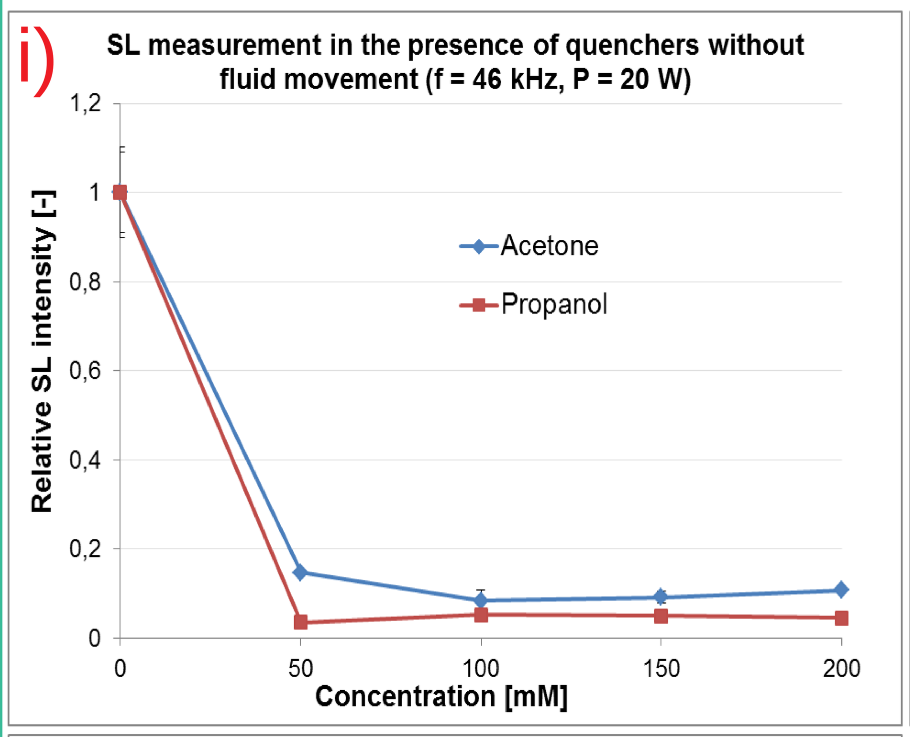
SL/SL_0 =/↑: Coalescence effects

SL/SL_0 ↓: **Transient** cavitation

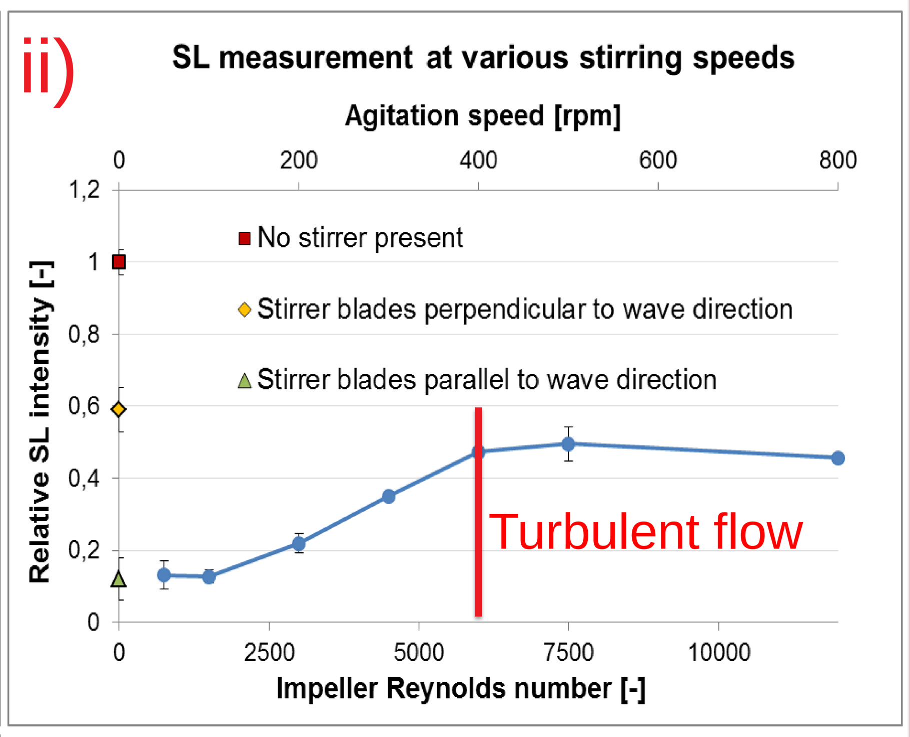
Results

Stirred batch reactor

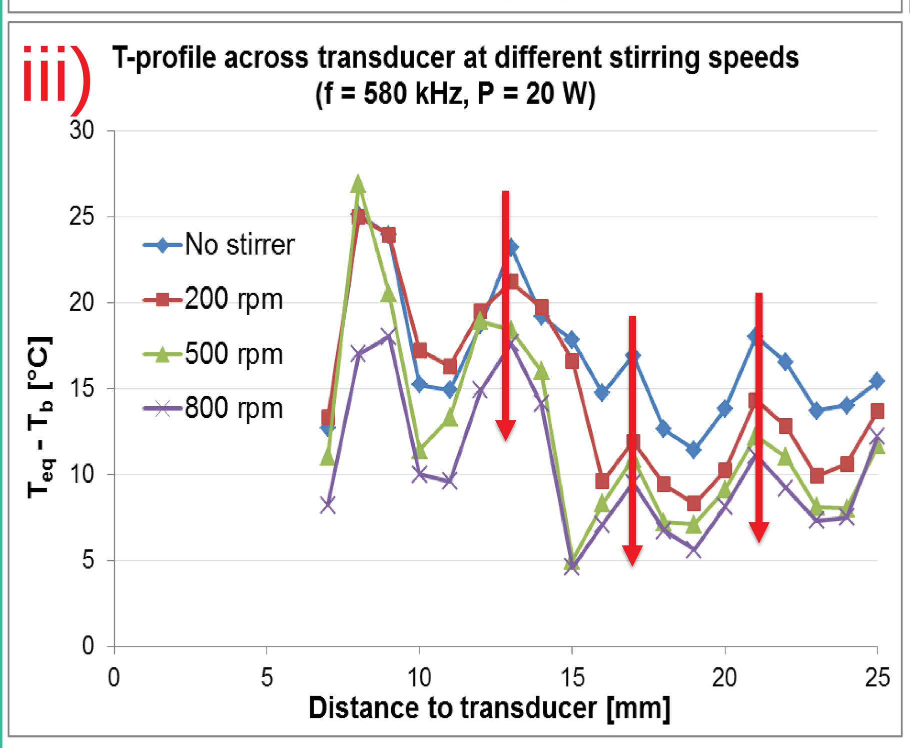
i)



ii)



iii)



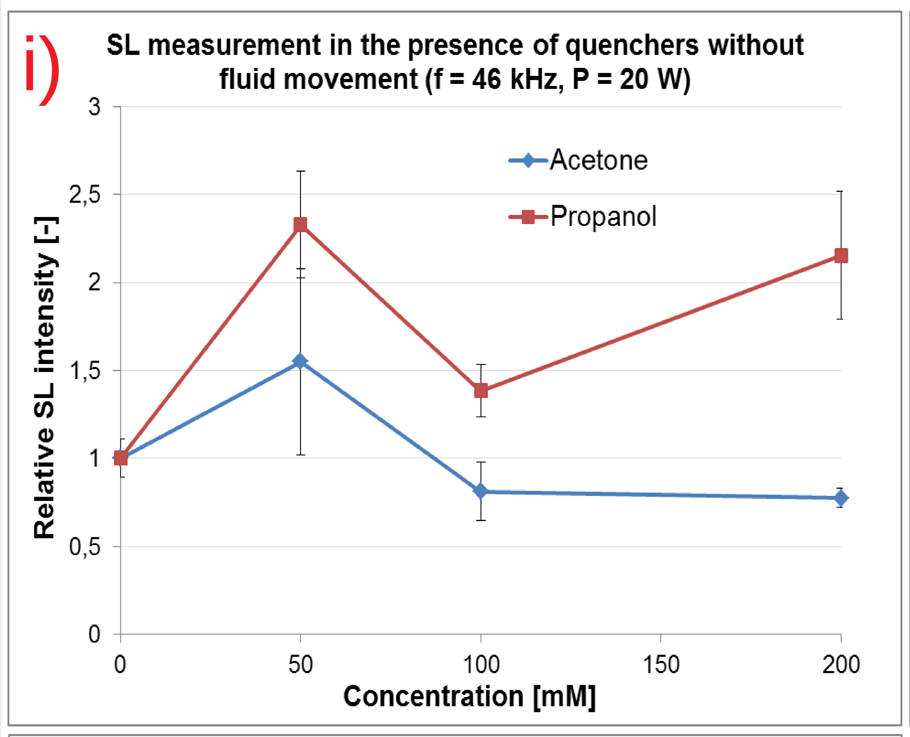
i) **Addition of quenchers:** Propanol SL/SL_0↓ stable cavitation

ii) **Overall ultrasonic intensity:** SL enhancement by stirring until turbulent regime is reached

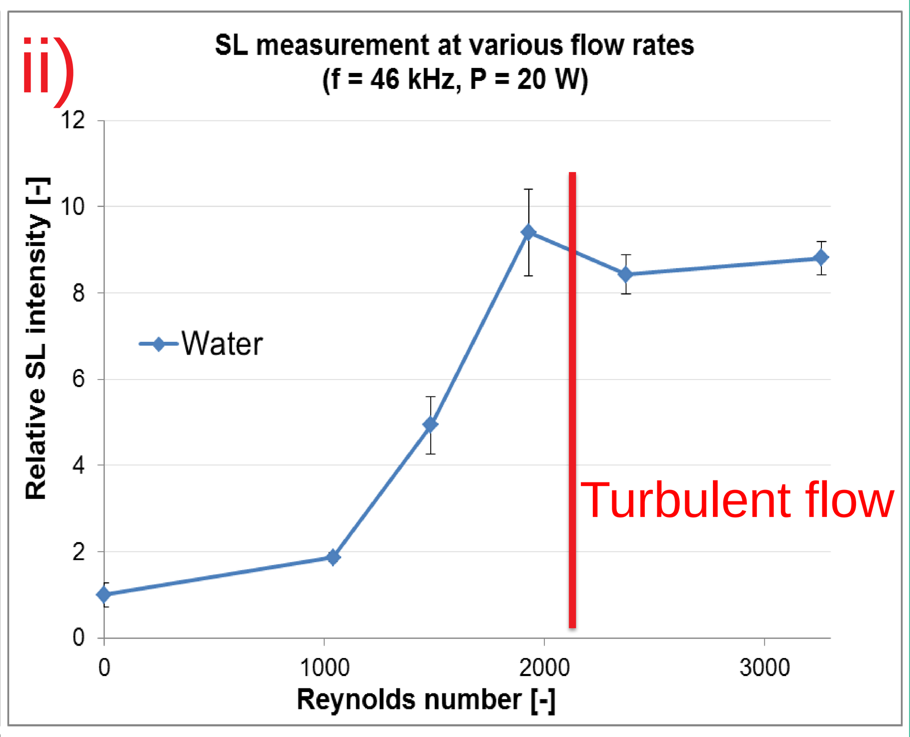
iii) **Local ultrasonic intensity:** Attenuation of the signal as stirring speeds increases

Flow reactor

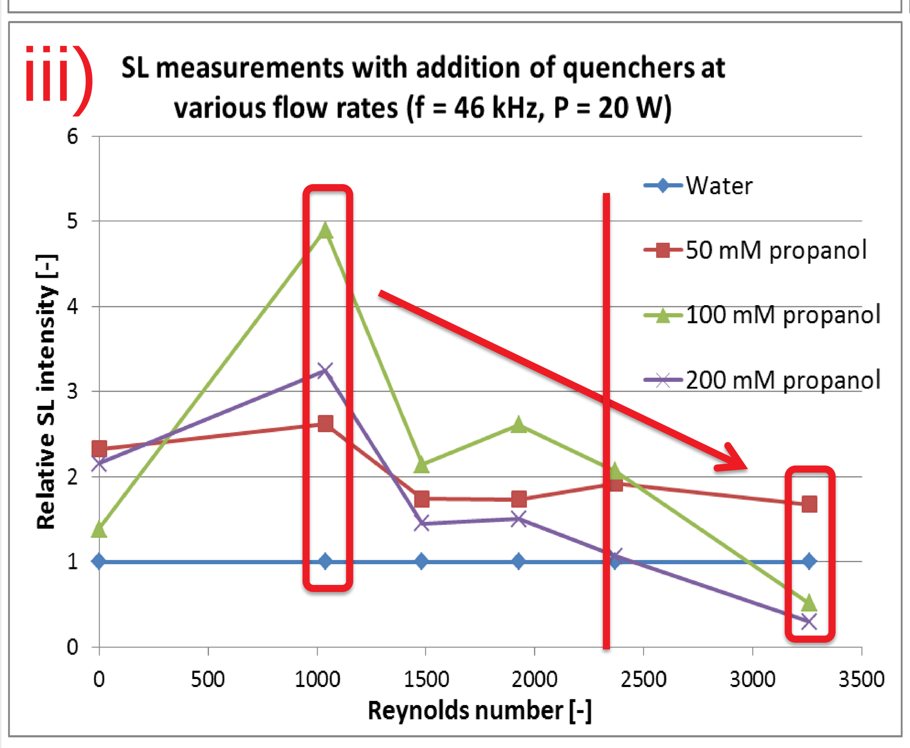
i)



ii)



iii)



i) **Addition of quenchers:** Propanol SL/SL_0↑ transient cavitation; Aceton SL/SL_0↓ confirmation of transient cavitation

ii) **Overall ultrasonic intensity:** SL enhancement by flow until turbulent regime is reached

iii) **Addition of quenchers in flow:** Laminar regime: transient cavitation; Turbulent regime: stable cavitation

Conclusions

- Same piezo-electric element does not always generate the same type of cavitation
- Cavitation type can alter in the presence of flow
- Effect of agitation or flow depends strongly on the used measurement technique:
  - *Local* ultrasonic intensity by coated thermocouple: attenuation of the signal as turbulence increases
  - *Overall* ultrasonic intensity by sonoluminescence: enhancement of the signal until turbulent flow regime is obtained

Acknowledgements

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References

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